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(71) Applicant: Dainippon Screen Mfg. Co., Ltd.
1-1, Tenjinkitamachi Teranouchi-agaru
4-chome Horikawa-dori
Kamikyo-ku Kyoto 602(JP)

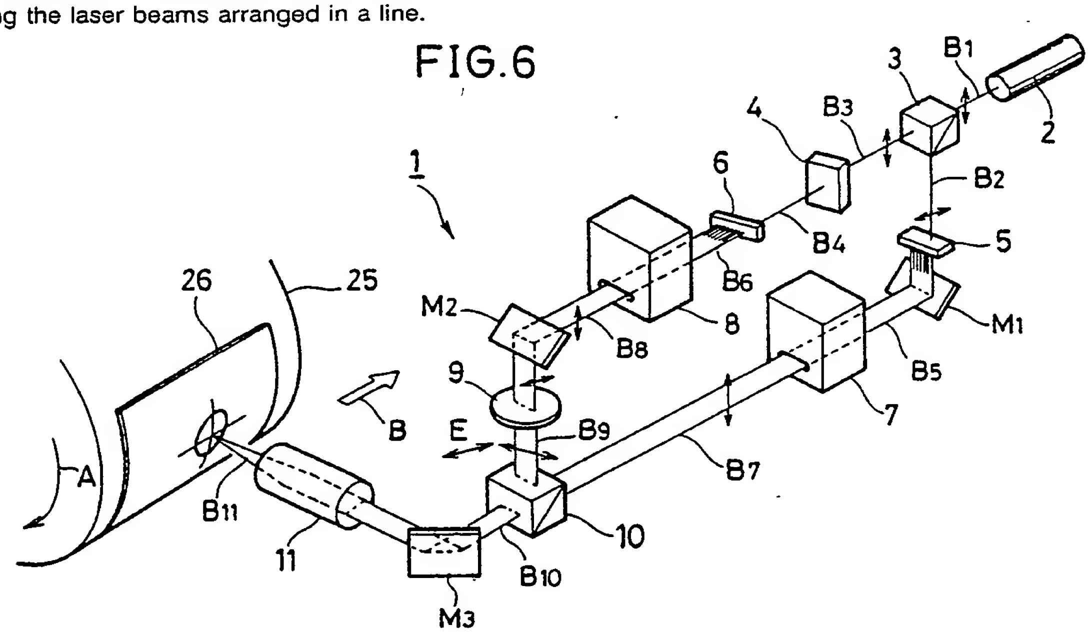
(72) Inventor: Okazaki, Masahide
c/o Dainippon Screen Kuze Plant 465-1
Tsukiyama-ch
Kuze Minami-ku Kyoto(JP)

(74) Representative: Goddar, Heinz J., Dr. et al
FORRESTER & BOEHMERT
Widenmayerstrasse 4/I
D-8000 München 22(DE)

(54) Method and apparatus for laser exposure in an image scanning/recording apparatus.

(57) A laser exposure apparatus of an image scanning recording apparatus comprises a single laser light source 2, a beamsplitter 3 for dividing a laser beam emitted from the single laser light source 2 into two laser beams, a modulator 7, 8 for modulating two laser beams in accordance with a recording signal, a half-wave retardation plate 9 for polarizing one of the beams in association with the other one of the beams so that the modulated laser beams constitute a pair of orthogonal polarization, a polarizing beamsplitter 10 for arranging two beams constituting a pair of orthogonal polarization with each other orthogonally in a line, and an optical system 11 for reducing the laser beams arranged in a line.

FIG.6



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Method and Apparatus for Laser Exposure in an Image Scanning/Recording Apparatus

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method of laser exposure applied to an image recording apparatus such as a laser printer, a color scanner for reproduction, or a laser plotter for manufacturing printed circuit boards, and more specifically to a method of laser exposure in which a plurality of laser recording beams scan in parallel an image recording surface.

Description of the Prior Art

Fig.1 is a perspective view of a conventional laser plotter.

The laser plotter comprises a console unit 21, a data processing unit 23 for arithmetically processing data inputted through a recording medium such as a magnetic tape, a data converting unit 70 for converting the data processed in the data processing unit 23 into desired recording signals, and a recording unit 80 for scanning and recording images on a photosensitive film 83 on a recording drum 82 based on the recording signals, and it exposes and records a master pattern of high precision of such as a printed circuit board and the like at high speed.

Fig. 2 is a schematic block diagram of the laser plotter shown in Fig. 1.

The laser plotter can be functionally divided into an image data forming unit 60, a data converting unit 70 and an image recording unit 80. The image data forming unit 60 forms vector data of the image based on the CAD (Computer Aided Design) data. The image data forming unit comprises a minicomputer 61 for calculating vector data, a CRT 62, a keyboard 63, a magnetic tape 64 or magnetic disc 65 for storing CAD data, and the like. The data converting unit 70 converts the vector data formed in the image data forming unit to dot data for output. The image recording unit 80 records binary image by zonally scanning a photosensitive material which will be the image recording surface, independently on/off controlling a plurality of multilaser beams which will be the output, based on a plurality of dot data supplied from the data converting unit 70. The image recording unit 80 comprises a laser unit for emitting recording laser, a recording drum 82 which is rotary driven with the photosensitive material 83 held thereon, a multichannel type modulator for separately outputting multilaser beams, and the like.

In the above described apparatus in which simultaneous recording is carried out by multibeams, the recording is carried in the following manner. Namely, beam spots are arranged adjacent to each other in an axial direction (subscanning direction) of the recording drum 82, whereby an image is formed in the axial direction. After the image is formed in the axial direction, the recording drum 82 is rotated in the peripheral direction (main scanning direction). Multibeams are formed in the subscanning direction based on the succeeding data. The above described operation is repeated to record the image.

Meanwhile, if laser beams emitted from a single laser source overlap with each other, the recording beams are disturbed because of interference. Therefore, the overlap of the recording beams has been avoided.

The distribution of light intensity of the laser beam emitted from a laser source is uneven and it has Gaussian distribution represented by the following equation (1), as shown in Fig. 3, for example.

$$I_y = I_0 \exp[-2(y/\omega)^2] \qquad (1)$$

where I_y: power density

y: distance from the center of the beam

ω: beam radius (where the power density becomes $1/e^2$ in association with the power density I_0 at the center)

As is apparent from the equation (1), the intensity of light becomes extremely low at the periphery of the beam.

If the laser beam has a Gaussian distribution, the beam spot diameter D (= 2ω) is defined as a beam diameter having the light intensity distribution of $1/e^2$ (about 13.5 %) of the light intensity at the center of the laser beam.

The overlap of the beams is defined as the overlap of the beam spot diameters D.

Therefore, if the zonal scanning lines are exposed and recorded by a plurality of such recording beams successively, the density of the portion corresponding to the border of the adjacent two beams cannot be high, so that the recording pattern which should have even density is seen to be divided by the scanning lines.

Methods for eliminating such a disadvantage are disclosed in, for example, Japanese Patent Laying-Open Gazette No. 118302/1977, Japanese Patent Laying-Open Gazette No. 69701/1978, Japanese Patent Laying-Open Gazette No. 203071/1985.

Fig. 4 shows a method disclosed therein. A serial beam spot line B13 is arranged inclined by a prescribed angle from the scanning direction, so that portions of neighboring scanning lines overlap with each other in recording. Therefore, the above described phenomenon in which the image is divided by the scanning lines can be eliminated.

However, since the serial beam spot line is arranged inclined from the scanning direction by a prescribed angle in the above described prior art, if the image signal output timings of respective recording beams are made equal, the image skews dependent on the angle of inclination. Therefore, a delay circuit is necessary to control the image signal output timing of each recording beam corresponding to the angle of inclination in order that the output image is aligned transversely in a line. The number of required delay circuits corresponds to the number of recording beams, thereby complicating the circuit.

Meanwhile, if the image recording surface is formed of a cylindrical surface of a rotary recording drum whose main scanning direction is the peripheral direction, the direction of the recording beam line B13 crosses diagonally with the axial direction of the recording drum 25 as is shown exaggerated in Fig. 4. Therefore, the shape of the beam (beam spot B14 of each recording beam) irradiated onto the cylindrical recording surface is deformed. Consequently, the light intensity distribution becomes uneven.

Another method for eliminating the above described disadvantages is disclosed in Japanese Patent Laying-Open Gazette No. 203071/1985.

A plurality of laser recording beams are transmitted through glass fibers and the beam output ends of the glass fibers are arranged in a staggered manner so as to form a beam spot line of staggered arrangement on the image recording surface, whereby portions of neighboring scanning lines overlap with each other after recording.

However, as a plurality of laser beams are transmitted through glass fibers, the above described prior art comprises the following problems.

Generally, the beam emitted from the beam output end of a glass fiber has a large angle of divergence (25 ~ 120°). Compared with the angle of divergence of a common laser beam which is about 1 m rad, it is very large, and therefore the loss of energy of the recording beam becomes large. In order to eliminate this problem, a collimator lens may be provided at the beam output end of each glass fiber. However, this makes the structure quite complicated and presents difficulty and disadvantage in practice.

SUMMARY OF THE INVENTION

Therefore, one object of the present invention is to provide method and apparatus for laser exposure capable of forming a clear recording pattern.

Another object of the present invention is to provide method and apparatus for laser exposure capable of forming a recording pattern of uniform density.

A further object of the present invention is to provide method and apparatus for laser exposure in which recording pattern is not divided by the scanning lines.

A still further object of the present invention is to provide a laser exposure apparatus capable of forming a recording pattern of uniform density at lower expense.

A still further object of the present invention is to provide method and apparatus for laser exposure employing lights forming a pair of orthogonal polarization.

A still further object of the present invention is to provide method and apparatus for laser exposure capable of forming a smoother recording pattern.

The above described objects of the present invention can be attained by a laser exposure apparatus comprising:

at least two laser beams which do not interfere with each other even when overlapped, each having a line of plurality of beam spots; beam modulating means for separately modulating at least two laser beams; beam synthesizing means for synthesizing at least two laser beams; and an optical system for projecting the laser beam synthesized in the synthesizing means on a recording medium.

Since the laser exposure apparatus comprises the above described components, a plurality of beam spot lines can be arbitrarily arranged to be projected on the recording medium. Therefore, a plurality of beam spot lines can be overlapped with each other by properly controlling the arrangement thereof, the light intensity between the beam spots is not reduced. Therefore, a laser exposure apparatus can be provided which is capable of forming a clear recording pattern.

According to a preferred embodiment of the present invention, the beam synthesizing means comprises a beam synthesizing means for synthesizing at least two laser beams so that portions thereof overlap with each other.

Since the exposure apparatus comprises the above described component, the laser beams can be overlapped with each other. Therefore, there will be no such portion having lower light intensity between the beams. Consequently, a laser exposure apparatus can be provided which is capable of forming a recording pattern of uniform density.

According to a preferred embodiment of the present invention, at least two laser beams which do not interfere with each other even when overlapped with each other are prepared by means for preventing interference of laser beams, the at least two laser beams are irradiated from a single light source, and the apparatus further comprises beam splitting means for dividing the laser beam irradiated from the said single light source into at least two laser beams.

Since the laser exposure apparatus comprises the above described component, only a single laser source is required. Consequently, a laser exposure apparatus can be provided in which a recording pattern of uniform density can be formed at low expense.

According to a more preferred embodiment of the present invention, the means for preventing interference of laser beams comprises polarized light converting means for converting at least two laser beams to form a pair of orthogonal polarization with each other.

Since the laser exposure apparatus comprises the above described component, two laser beams which do not interfere with each other even when overlapped with each other can be readily prepared. Therefore, a laser exposure apparatus can be provided which is capable of forming a recording pattern of uniform density having a simple structure.

According to a further embodiment of the present invention, the means for preventing interference between laser beams comprises means for changing optical path difference between the laser beams to be wider than the coherence length.

Since the laser exposure apparatus comprises the above described component, a laser exposure apparatus can be provided which is capable of forming a recording pattern of uniform density without employing a polarizing apparatus.

According to a still further preferred embodiment of the present invention, the beam synthesizing means comprises a polarizing beamsplitter. The polarizing beamsplitter transmits approximately 100 % of a prescribed polarized light. Therefore, the laser exposure apparatus can be provided in which there will be no loss of the irradiated laser beam.

According to a still further preferred embodiment of the present invention, a method for laser exposure of an image scanning recording apparatus in which a plurality of laser recording beams are irradiated on an image recording surface to form a serial beam spot line, the laser recording beam scans in a main scanning direction crossing the direction of the spot lines to expose the recording medium, comprises the steps of:

preparing at least two laser beams which do not interfere with each other even when overlapped, each having a plurality of beam spot lines; modulating separately at least two laser beams; aligning respective serial beam spot lines of at least two laser beams in the said line direction such that portions overlapped with each other; and exposing the said recording medium by using the aligned beam spot lines.

Since the method for laser exposure comprises the above described steps, the recording medium is irradiated by laser beams overlapped with each other. Therefore, there will be no such portion having lower light intensity between beams. Consequently, a method of laser exposure capable of forming a recording pattern of uniform density can be provided.

These objects and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing a conventional laser plotter;
Fig. 2 is a schematic block diagram of the laser plotter shown in Fig. 1;
Fig. 3 shows intensity distribution of the laser beam;
Fig. 4 shows an improved laser exposure recording method of the prior art;
Fig. 5 shows a Poincaré sphere illustrating the state of polarized light;
Fig. 6 is a perspective view of a laser exposure apparatus employing a pair of orthogonal polarization;
Fig. 7 shows the state of alignment of the beams;
Fig. 8 shows a beam synthesizer;
Fig. 9 shows a function of a beam shifter;
Fig. 10 shows the distribution of quantity of light of the beam spot line;
Fig. 11 shows the distribution of the quantity of light of the spot line when the interval between the beam spot lines is wide;
Figs. 12A and 12B show modifications of the beam synthesizer;
Fig. 13 shows the structure of a second embodiment;
Figs. 14 and 15 show modifications of the second embodiment;
Figs. 16 to 20 show embodiments employing pairs of orthogonal polarization of circularly polarized light or elliptically polarized light;
Fig. 21 is a perspective view of a laser exposure apparatus utilizing laser beams with the optical path difference wider than the coherence length;
Fig. 22 is a modification of the embodiment shown in Fig. 21;
Fig. 23 is a perspective view of a laser exposure apparatus utilizing separate two laser beams;
Fig. 24 is a modification of the embodiment shown in Fig. 23;
Fig. 25 shows a staggered arrangement of beam spot lines; and
Fig. 26 shows the process of forming the staggered arrangement of the recording beam lines.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Since the present invention relates to an exposure apparatus utilizing laser beams, the embodiment will be described using the laser plotter shown in Figs. 1 and 2.

(Embodiment 1)

First, description will be given of an embodiment in which the apparatus utilizes laser beams constituting a pair of orthogonal polarization.

Prior to the description of the embodiment, the pair of orthogonal polarization will be explained.

The state of polarization of light is defined by the state of the locus of the oscillation vector of light (in case of laser beams, normally the electric vector). The locus is generally represented by an ellipse under the following condition.

(1) Azimuth of an ellipse major axis θ [$0^\circ \leq \theta < 180^\circ$]

An angle of the major axis of an ellipse in association with a certain reference axis

(2) Ellipticity angle β [$-45^\circ \leq \beta \leq 45^\circ$]

An angle whose tangent being the proportion of the major axis l and the minor axis m of an ellipse. That is $\beta = \pm \tan^{-1} m/l$. The positive and negative signs of the ellipticity angle β represents the handedness, that is, the right-handed elliptically polarized light (positive) or left-handed elliptically polarized light (negative).

The above described condition represents a general elliptically polarized light. If $\beta = \pm 45^\circ$, the locus of the oscillation vector of the light becomes a circle, which state is called a circularly polarized light. If $\beta = 0^\circ$, the locus of the oscillation vector of the light becomes a line, which is called a linearly polarized light.

The Poincaré sphere representation shown in Fig. 5 is generally used as a method for representing the

above described state of polarized light. (For example, "Kessho Kogaku (crystal optics)" by Optics Division, the Japan Society of Applied Physics, published by Morikita Shuppan Inc. on August 27, 1984, page 146 and in "Kogaku (optics)" by Kozo Ishiguro, published by Kyoritsu Shuppan Inc. on February 15, 1980, page 20). According to the Poincaré sphere representation, it is defined that a point on a sphere surface modeled after a globe corresponds to a specified state of polarized light. The latitude La of an arbitrary point S shown in Fig. 5 represents twice the ellipticity angle β while the longitude Lb thereof represents twice the azimuth of an ellipse major axis θ. In the Poincaré sphere representation, the right-handed polarized light corresponding to positive ellipticity angle is arranged in the northern hemisphere, while a left-handed polarized light corresponding to the negative ellipticity angle is arranged in the southern hemisphere. The linear polarized light, that is, the ellipticity angle $\beta = 0$, is arranged on the equator, and the right-handed circularly polarized light and the left-handed circularly polarized light are arranged on both poles.

A pair of polarized lights satisfying the following relation is called orthogonal polarization: namely, the difference of the azimuth of an ellipse major axis is 90°, the absolute value of the ellipticity angle of each polarized light is equal to each other and the sign thereof, that is, the handedness, is opposite to each other. According to the Poincaré sphere representation, the orthogonal polarization is denoted by a pair of polarized lights which is arranged on positions where the difference of the longitude is 180° and the absolute value of the latitude is the same with the signs opposed to each other. Therefore, in the Poincaré sphere representation, two polarized lights positioned in point symmetry about the point 0 constitute a pair of orthogonal polarization. In elliptically polarized light, the pair of orthogonal polarization is a pair of two elliptically polarized light having their major axes intersecting orthogonally with each other, the proportion of the major axis l and the minor axis m being equal with each other, and the handedness opposite to each other. In the circularly polarized light, the pair is the pair of two circularly polarized lights having opposite handedness, and in the linearly polarized light, the pair is the pair of two linearly polarized lights having their planes of polarization intersecting orthogonally with each other.

In case of coherent light such as laser beam, the lights constituting the pair of orthogonal polarization do not interfere with each other even when they are overlapped with each other

(Embodiment 1-1)

Fig. 6 is a perspective view of a laser exposure apparatus 1 utilizing laser beams having planes of polarization intersecting orthogonally with each other as the above described pair of orthogonal polarization. The laser exposure apparatus 1 comprises a laser light source 2, a beamsplitter 3 for splitting laser beam, a beam shifter 4 for shifting the laser beam by a prescribed quantity, multitype beamsplitters 5 • 6 for splitting beams, multichannel type light modulators 7 • 8 for modulating beams for recording, half-wave retardation plate 9 for preventing disturbance of the recording beam, a beam synthesizer 10 for aligning beams, and a beam reducing optical system 11 for reducing beams for recording. The laser beam is irradiated in the axial direction of the recording drum 25 on which the images are recorded, and a serial beam spot line B12 such as shown in Fig. 7 is formed on a photosensitive film 26 attached on the recording drum 25. In Fig. 5, M1 to M3 denote mirrors.

The laser light source 2 comprises an argon laser, helium • neon laser, a laser diode, or the like, which emits a linearly polarized light beam B1.

The beamsplitter 3 divides the light beam B1 from the laser source 2 into an oriented beam B2 and a straight beam B3. The multitype beamsplitters 5 • 6 respectively divide single beam B2 • B4 into a plurality of parallel beams to be emitted as parallel beam lines B5 • B6. The multitype beamsplitters 5 • 6 are disclosed in, for example, Japanese Patent Laying-Open Gazette No. 122135/1977 and in Japanese Patent Laying-Open Gazette No. 19101/1985. The multitype beamsplitters 5 and 6 divide a single incidental beam to a plurality of parallel beams utilizing multiple internal reflections of a glass plate having parallel planes. One plane of the glass plate is coated to form a perfect reflective surface and the other plane is coated such that the transmittance gradually changes. By doing so, the quantity of light of each of the parallel beam lines B5 and B6 emitted from the other plane become approximately uniform.

The multichannel type light modulators 7 and 8 are provided for independently modulating each of the beams in the parallel beam lines B5 and B6 for emitting recording beam lines B7 and B8 for image recording. An acoustic optical modulator, an electro-optic modulator and the like are used as the light modulator. The multichannel type acoustic optical modulators 7 and 8 are disclosed in, for example, Japanese Patent Laying-Open Gazette No. 10742/1983 and in Japanese Patent Laying-Open Gazette No. 14135/1983, in which a plurality of acoustictransducers are attached onto a single acoustic optical medium. The parallel beam lines B5 and B6 irradiate the acoustic optical medium portion corresponding to the said

acoustic transducer. Each of the incidental laser beams is independently modulated based on control signals generated in accordance with pattern signals so as to be emitted as parallel recording beam lines B7 and B8.

The beam synthesizer 10 receives the recording beam lines B7 and B9 respectively modulated by the modulators 7 and 8 from two directions intersecting orthogonally with each other, and aligns the directions thereof to emit a recording beam line B10. A common beamsplitter is arranged reversely to synthesize beams. The beam lines are synthesized such that the beams belonging to the beam lines B7 and B9 are aligned with each other (the beams belonging to the lines B7 and B4 are arranged to be adjacent to each other successively).

The recording beam line B10 synthesized by the beam synthesizer 10 is reduced by a beam reducing optical system, and irradiates the surface of a photosensitive film 26 mounted on the recording drum 25. Consequently, a serial beam spot line B12 such as shown in Fig. 7 is formed.

The beam spot line B12 is formed by shifting adjacent beam spots a and b by one half of the spot diameter D using the said beam shifter 4 and by aligning the adjacent beam spots a and b in a subscanning direction (arrow B in Fig. 6) which intersects orthogonally with the main scanning direction (arrow A in Fig. 6) by the said beam synthesizer 10.

The said beam shifter 4 comprises a transparent parallel flat plates such as shown in Fig. 9. By setting the angle $\theta 1$ formed by the normal N of the plane of the parallel flat plate and the laser beam B3 at an angle defined by the following equation, the emitted light B4 is shifted in parallel by a desired pitch P (here the distance enough to shift the beam spot line by D/2).

$$P = t \cdot (1 - \cos\theta_1 / \sqrt{n^2 - \sin^2\theta_1}) \cdot \sin\theta_1$$

where t: thickness of the parallel flat plate 4
n: refractive index of the parallel flat plate 4

The half-wave retardation plate 9 is provided to prevent disturbance of the recording beam caused by the interference between the overlapped beam spots a and b of the beam spot line B12 shown in Fig. 7. The half-wave retardation plate 9 emits a recording beam line B9 in which the plane of polarization of each laser beam in one recording beam line B8 is rotated for approximately 90° in association with the plane of polarization of each laser beam in the other recording beam line B7.

Namely, the half-wave retardation plate 9 converts an arbitrary polarized light on the Poincaré sphere shown in Fig. 5 into a polarized light placed at a position rotated by 180° about an axis passing through the equator and the point 0. The central axis is determined by the rotary position of the half-wave retardation plate 9. Therefore, by adjusting the rotary position of the half-wave retardation plate 9, an arbitrary polarized light on the Poincaré sphere can be converted into a polarized light on a position of point symmetry about the point 0. Therefore, by adjusting the rotary position of the half-wave retardation plate 9, the linearly polarized light positioned on the equator of the Poincaré sphere can be converted into a linearly polarized light on the point of symmetry about the point 0, namely, the linearly polarized light with the plane of polarization intersecting orthogonally with the linearly polarized light.

The mark ↕ appended to the beams B1 to B9 show the planes of polarization of the beams of linearly polarized light. The mark ⊗ shown in Fig. 8 shows that the plane of polarization of the beam is in the vertical direction to the surface of the sheet. These marks denote the same idea in the following figures.

Therefore, according to the above described structure, the planes of polarization of the adjacent recording beams are crossing orthogonally with each other, whereby there will be no interference. Therefore, the adjacent recording beams may be overlapped with each other. When zonal scanning lines are recorded by utilizing the beam spot line B12 in which one half of the beam diameter D of the beams are overlapped with each other, the distribution of the quantity of light will be as flat as the solid line C in Fig. 10.

Solid line C in Fig. 11 illustrates the distribution of the quantity of light when the function between the beam diameter D and the pitch P between the adjacent beam spots is selected to be P = 0.6D. In this case also, a generation of dark portion can be prevented by selecting a photosensitive film having a high γ value.

The beam synthesizer 10 may be used such that recording beam lines B7 and B9 enter from two directions which do not form a right angle with each other and the serial beam spot line B12 is formed on the recording surface through the beam reducing optical system 11.

The serial beam spot line B12 may be formed by using an optical system comprising a mirror M such as shown in Fig. 12B as a beam synthesizing means instead of the beam synthesizer 10.

(Embodiment 1-2)

Fig. 13 corresponds to Fig. 6, showing an apparatus in accordance with another embodiment of the present invention. The apparatus of this embodiment differs from the first embodiment in the following points. Namely, a mirror M4 is provided finely adjustable in the direction of the arrow E instead of the beam shifter 4, and means 9′ for orthogonally intersecting planes of polarization comprising two mirrors M5 and M6 is provided instead of the half-wave retardation plate 9.

The mirror M4 is moved and adjusted by a desired pitch P in the direction of the arrow E. Consequently, one recording beam B7 which is reflected at right angle at the mirror M4 to enter the beam synthesizer 10 is shifted from the other recording beam line B8 by a desired pitch P while they are aligned with each other.

Out of the beams B2 and B3 divided by the beamsplitter 3 which are parallel linearly polarized light, one beam B3 is reflected to a different plane through the means 9′ for orthogonally intersecting the planes of polarization consisted of two mirrors M5 and M6. Consequently, the plane of polarization thereof intersects orthogonally with the plane of polarization of the other beam B2.

In the above described two embodiments, instead of arranging the multitype beamsplitters 5 and 6 at the positions shown in Fig. 6 or 13, one multitype beamsplitter may be arranged between the beamsplitter 3 and the laser source 2 as shown in Figs. 14 and 15.

Although description was given of a case in which one plane of polarization of the overlapping recording beams is the main scanning direction and the other is the subscanning direction in the above described embodiment, the planes of polarization may be intersect with each other with the planes respectively inclined by 45° from the main scanning direction (or the subscanning direction), respectively. Various beamsplitters such as a beamsplitter, a half mirror, a Pellicle beamsplitter and the like may be used as the beams synthesizer 10 and, especially a polarizing beamsplitter is preferred.

A multilayer dielectric coating is applied on an inclined surface in the polarizing beamsplitter. When the beam B7 which is P polarized light is irradiated on surface, approximately 98 % thereof is transmitted. If the beam B9 which is S polarized light is irradiated on the surface, approximately 98 % thereof is reflected. The P polarized light denotes a polarized light whose plane of polarization is parallel to an arbitrary determined plane while S polarized light is orthogonal to the P polarized light.

Even if the P polarized beam and S polarized beam enter the polarizing beamsplitter with the planes of polarization not accurately intersecting orthogonally with each other, the P polarized beam transmitted through the inclined surface having the multilayer dielectric coating and the S polarized beam reflected therefrom are emitted with accurate planes of polarization, respectively. Therefore, the planes of polarization of both beams precisely intersect orthogonally with each other.

Therefore, by employing the polarizing beamsplitter, mechanism for adjusting angles for accurately intersecting the planes of polarization orthogonally with each other can be eliminated, and the loss of energy in synthesizing laser beams can be extremely lowered.

Prisms employing crystal of double refraction such as a Rochon prism can be used in the similar manner as the polarizing beamsplitter.

(Embodiment 1-3)

In the above described embodiments, pairs of linearly polarized light having planes of polarization intersecting orthogonally with each other are used as the pair of orthogonal polarization. Alternately, a pair of orthogonal polarization of two circularly or elliptically polarized light may be utilized as in the apparatus of the embodiment shown in Figs. 16 to 19.

The apparatus shown in Fig. 16 is a modification of the apparatus of the embodiment shown in Fig. 14. The half-wave retardation plate 9 is eliminated and quarter-wave retardation plates 32 and 34 are provided between the multichannel type light modulators 7 and 8 and the beam synthesizer 10 for converting the linearly polarized beams B7 and B8 into circularly polarized beams B32 and B34 forming a pair of orthogonal polarization.

The quarter-wave retardation plates 32 and 34 convert an arbitrary polarized light on the Poincaré sphere surface shown in Fig. 5 into a polarized light arranged on the position rotated by 90° about an axis

passing through the equator and the point 0. The central axis is determined by the rotary position of the quarter-wave retardation plates 32 and 34. Therefore, by adjusting the rotary position of the quarter-wave retardation plate 32 and 34, all linearly polarized lights placed on the equator of the Poincaré sphere can be converted either to the right-handed circularly polarized light or left-handed circularly polarized light positioned on each of the poles of the Poincaré sphere.

In the apparatus of this embodiment, the beam B7 modulated by the modulator 7 is converted into a right-handed circularly polarized light beam B32 by the quarter-wave retardation plate 32 and the beam B8 modulated by the modulator 8 is converted into a left-handed circularly polarized light beam B34 by the quarter-wave retardation plate 34. The respective beams B32 and B34 are synthesized by the synthesizer 10. On this occasion, since the right-handed circularly polarized light beam B32 and the left-handed circularly polarized light beam B34 constitute a pair of orthogonal polarization, there will be no interference between the two even when they are overlapped with each other. It goes without saying that the right-handed circularly polarized light and the left-handed circularly polarized light may be inverted with each other.

The apparatus shown in Fig. 17 is a modification of the apparatus of the embodiment shown in Fig. 13, which further comprises quarter-wave retardation plates 32 and 34 provided between the light modulators 7 and 8 and the beam synthesizer 10. As is the same as the apparatus shown in Fig. 16, the circularly polarized light beams B32 and B34 having opposite handedness can be overlapped without interference.

In this apparatus of the embodiment, the planes of polarization of the beams B7 and B8 irradiating the quarter-wave retardation plates 32 and 34 are orthogonally intersecting with each other, so that the beams B32 and B34 may be the elliptically polarized lights constituting a pair of orthogonal polarization. Namely, in the Poincaré sphere representation, two polarized lights arranged on positions point symmetry about the point 0 on the equator will be the right-handed circularly polarized light and left-handed circularly polarized light if they are respectively rotated by 90° about an axis passing through the point 0 and orthogonal to the axis connecting the two polarizations, by two quarter-wave retardation plates 32 and 34 one in the direction toward the North Pole and the other in the direction toward the South Pole. If they are rotated in the direction to the North Pole and to the South Pole, respectively, by 90° about another axis passing through the equator and the point 0, they will be two elliptically polarized lights constituting a pair of orthogonal polarization.

The apparatus shown in Fig. 18 is similar to that shown in Fig. 17. In the device, linearly polarized light beams B7 and B8 with their planes of polarization crossing orthogonal with each other irradiate the quarter-wave retardation plates 32 and 34, and are converted into circularly or elliptically polarized light beams B32 and B34, respectively, constituting a pair of orthogonal polarization. The manner of generating the beams B7 and B8 having the planes of polarization crossing orthogonal with each other is different from that in the embodiment shown in Fig. 17. More specifically, in the apparatus in accordance with this embodiment, a polarizing beamsplitter 30 is used as the beamsplitter and, in addition, the rotary position of the laser source 2 is adjusted beforehand so that the beam B1 irradiates the polarizing beamsplitter 30 with the plane of polarization thereof inclined by 45° in association with the reference plane. Consequently, the beam B1 is separated into a S polarized beam B2 and P polarized beam B3 having their planes of polarization crossing orthogonally with each other without loss of quantity of light by the polarizing beamsplitter 30. Therefore, the planes of polarization of the beams B7 and B8 irradiating the quarter-wave retardation plate 32 and 34 orthogonally intersect with each other as in the apparatus in accordance with the embodiment shown in Fig. 17.

In the apparatus of this embodiment, if the quarter-wave retardation plates 32 and 34 are omitted, linear polarized lights having the planes of polarization of the overlapping recording beams orthogonally intersecting with each other can be provided as in the embodiment shown in Fig. 6.

Fig. 19 shows a modification of the apparatus shown in Fig. 16, in which a quarter-wave retardation plate 36 is provided between the beam synthesizer 10 and the beam reducing optical system 11. In the apparatus of this embodiment, the overlapping beams of the beam B10 emitted from the beam synthesizer 10 have their planes of polarization intersecting orthogonally with each other. Therefore, the beam B10 can be converted into a beam B36 of circularly polarized light or elliptically polarized light with the overlapping beams constituting the pair of orthogonal polarization by a single quarter-wave retardation plate 36.

Namely, in the Poincaré sphere representation, if two polarized lights arranged on positions in point symmetry about the point 0 on the equator are rotated by 90° about an axis passing through the point 0 and crossing orthogonally with an axis connecting two lights by a single quarter-wave retardation plate 36, these polarized lights become a right-handed circularly polarized light and the left-handed circularly polarized light. If they are rotated by 90° about another axis passing through the equator in the point 0, they will be two elliptically polarized lights constituting a pair of polarization.

Different from the apparatus shown in Figs. 16 to 18, the loss of quantity of light can be reduced by employing a polarizing beamsplitter as the beam synthesizer 10 in the apparatus of this embodiment.

Fig. 20 shows a modification of the apparatus shown in Fig. 14 in which a quarter-wave retardation plate 38 is provided in front of the beamsplitter 3. In the apparatus of this embodiment, the beam from the laser source 2 is converted into a circularly polarized light or elliptically polarized light by the quarter-wave retardation plate 38. Thereafter, the beam is splitted by the beamsplitter 3 to provide beams B7 and B8 having the same state of polarization. A half-wave retardation plate 9 is adjusted so that one beam B8 is converted into a circularly polarized light or elliptically polarized light at the position of point symmetry in the Poincaré sphere. Therefore, a beam B9 constituting a pair of orthogonal polarization with the beam B7 can be provided.

Meanwhile, a laser source emitting a laser beam having a prescribed state of polarized light is generally a linear polarized light laser only. Therefore, in the above described embodiments, the laser beams emitted from the laser light source are described as linear polarized lights. However, if there is any laser light source capable of emitting circularly or elliptically polarized lights, the quarter-wave retardation plate 38 shown in the embodiment of Fig. 20, for example, can be omitted.

(Embodiment 2)

Description will be given of a second embodiment of the present invention, which is an apparatus employing a laser beam provided with an optical path difference wider than the coherence length. Description of the same or corresponding portions as the above described embodiments will be omitted appropriately.

The basic structure of the laser exposure apparatus 1 in accordance with this embodiment comprises, as shown in Fig. 21, a laser light source 2, a beamsplitter 3, a beam shifter 4, a multitype beamsplitters 5 • 6, multichannel type light modulators 7 • 8, a right-angle prism 40, a beam synthesizer 10 and a beam reducing optical system 11. It is structured such that a serial beam spot line B12 such as shown in Fig. 6 is formed in the axial direction of the recording drum 25. The beam spot line B12 is formed by alternating arrangement of the beam spots from the beam B7 and B8 as in the above described embodiment. M7 denotes a mirror.

The said right-angle prism 40 is provided in a detour light path F to adjust the optical path difference L between a straight light path E and the detour light path F to be a desired distance wider than the coherence length. The optical path difference L is approximately the same as the sum of L1, L2 and L3 shown in Fig. 21, and the optical path difference L can be adjusted by moving the right-angle prism 40 in the direction of the arrow H. The coherence length can be represented by the following equation (II), which is, in general, about 10 cm in the case of He-Ne laser and several cm in the case of Ar laser.

$$\ell = \frac{C}{\Delta \nu} \qquad \ldots (II)$$

where ℓ: coherence length

$\Delta\gamma$: line width

C: light velocity

If the optical difference L is twice the length of L3 and is longer than the coherence length, the prism can be omitted and the position of the mirror M9 may be adjusted such that the beam path is changed from F to B3 as shown in Fig. 22.

According to the above described structure, the interference can be eliminated by providing the optical path difference L longer than the coherence length between adjacent recording beams, so that the adjacent recording beams can be overlapped with each other.

In the apparatus of the embodiment shown in Fig. 21, a plurality of mirrors may be used instead of the right-angle prism 40 to provide the optical path difference L longer than the coherence length.

Alternately, either one of the light paths E and F is further divided into two, the optical path differences L longer than the coherence length are provided respectively between the three light paths and they may be overlapped with each other.

(Embodiment 3)

Description will be given of a third embodiment of the present invention, which is an apparatus utilizing laser beams from separate laser light sources. Description of the same or corresponding portions as the above described apparatuses will be omitted appropriately. The laser exposure apparatus 1 in accordance with this embodiment comprises, as shown in Fig. 23, two laser light sources 42 • 43, multitype beamsplitters 5 • 6, multichannel type light modulators 7 • 8, a beam synthesizer 10, and a beam reducing optical system 11. It is structured such that a serial beam spot line B12 such as shown in Fig. 7 is formed in the axial direction of the recording drum 25. As in the apparatuses in the above described embodiments, the beam spot line B12 is formed by alternately arranging beam spots from the beams B7 and B8.

According to the above described structure, the adjacent recording beams are emitted from separate laser light sources. Therefore, there will be no interference. Consequently, adjacent recording beams can be overlapped with each other.

Fig. 24 shows a still further embodiment. The apparatus of this embodiment is different from the above described apparatus in the following points, namely, an arrayed laser diodes 52 • 53 having a plurality of exit edges are employed instead of the laser light source 42 • 43 and the multitype beamsplitters 5 • 6 shown in Fig. 23, and a mirror M_4 is provided finely adjustable in the direction of the arrow E. As is well known, the laser diode itself has the modulation function, so that the multichannel type light modulators 7 • 8 shown in Fig. 3 can be omitted in this apparatus. The numeral 54 denotes a collimator lens.

A polarizing beamsplitter is preferably used as the beam synthesizer 10 shown in Figs. 23 and 24 as in the embodiments shown in Figs. 6, 13 to 15 and 19. By doing so, the loss of the energy of the laser beam can be minimized.

In the apparatuses of all the embodiments, the serial beam spot line B12 is formed by aligning each of the beam spots in a line. For example, in the apparatus of the embodiment shown in Fig. 6, a beamsplitter, a polarizing beamsplitter, a half mirror and the like is used as the beam synthesizer 10 and the beam synthesizer 10 may be moved in the direction of the arrow E to provide the staggered beam spot line B12 such as shown in Fig. 25.

The beam spot line B12 of the staggered arrangement comprises front spot line B14 positioned forward in the scanning direction (the direction of the arrow A) and a rear spot line B13 positioned behind the front spot line B14. The recording beam lines B7 and B8 are respectively emitted as the recording beam line B10 of the staggered arrangement through the beam synthesizing means 10, thereby forming the two spot lines.

The rear spot line B13 is spaced apart from the forward spot line B14 by a required interval L1 to avoid overlapping with the forward spot line B14. The spot lines B13 and B14 are shifted from each other by a prescribed pitch P_1 (in this case one half of the spot diameter D) in the subscanning direction (arrow B) intersecting orthogonally with the main scanning direction.

The interval L1 is selected by adjusting the interval L0 shown in Fig. 26 by moving the beam synthesizing means 10 or the mirror M2 in the direction of the arrow E shown in Fig. 6.

In this structure, the front spot line B14 and the rear spot line B13 shown in Fig. 25 do not overlap with each other. Therefore, even if the half-wave retardation plate 9 of Fig. 6 is omitted, there will be no interference. In addition, if the half-wave retardation plate 9 is used and a polarizing beamsplitter is used as the beam synthesizing means 10, then the loss of the energy can be minimized in synthesizing beams. In such case, even if the front spot line B14 and the rear spot line B13 overlap with each other, there will be no interference of the laser beams. Therefore, the interval L1 in Fig. 25 can be made smaller. The staggered arrangement of the beam spot lines can be applied not only to the apparatus of the embodiment shown in Fig. 6 but also to the apparatuses of other embodiments.

The present invention is not limited to the above described various embodiments but is applicable with various modifications.

For example, in the above described embodiments, recording may be carried out by two beams without using the multitype beamsplitters 5 • 6.

In the above embodiments, a photosensitive film as a recording medium is attached on a recording drum and the recording is carried out on the photosensitive film. The present invention can be applied to the apparatuses in which other photosensitive materials are used as the recording media.

In the above described embodiments, the present invention is applied to an image recording apparatus of rotary drum system in which the scanning and exposure is carried out by rotating the recording drum. However, as shown in the Patent Laying-Open Gazette No. 67277/1981, the present invention may be applied to image recording apparatuses of a flying spot system in which the laser beam is reciprocated on the recording medium employing a rotary polygon mirror, galvano mirror, and the like.

According to the present invention, recording can be carried out using beams without interference of adjacent recording beams. Therefore, portions of the recording beams can be overlapped with each other to form a beam spot line in the direction orthogonal to the main scanning direction. Consequently, a laser exposure apparatus can be provided capable of forming a recording pattern of uniform density.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the scope of the present invention being limited only by the terms of the appended claims.

The features disclosed in the foregoing description, in the claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. A laser exposure apparatus of an image scanning recording apparatus in which a plurality of laser recording beams irradiate an image recording surface to form a serial beam spot line, and the laser recording beams are moved to scan in a main scanning direction orthogonally intersecting said spot line to expose the recording medium, comprising:

at least two laser beams which do not interfere with each other even if overlapped, each having a plurality of beam spot lines:

beam modulating means for independently modulating said at least two laser beams:

beam synthesizing means for synthesizing said at least two laser beams; and

an optical system for projecting the laser beam synthesized by said beam synthesizing means on said recording medium.

2. A laser exposure apparatus of an image scanning recording apparatus according to claim 1, wherein said beam synthesizing means comprises beam synthesizing means for synthesizing said at least two laser beams so that portions thereof overlap with each other.

3. A laser exposure apparatus of an image scanning recording apparatus according to claim 2, which further comprises:

means for preventing interference of laser beams for preparing said at least two laser beams which do not interfere with each other even if overlapped:

a single laser light source for irradiating said at least two laser beams; and

beams splitting means for splitting the laser beam irradiated from said single laser light source into at least two laser beams.

4. A laser exposure apparatus of an image scanning recording apparatus, wherein said means for preventing interference of laser beams comprises polarizing means for generating two laser beams constituting a pair of orthogonal polarization.

5. A laser exposure apparatus of an image scanning recording apparatus according to claim 4, wherein said polarizing means comprises linear polarizing means for converting said two laser beams into a pair of linear linearly polarization.

6. A laser exposure apparatus of an image scanning recording apparatus according to claim 5, wherein said linear polarizing means comprises a half-wave retardation plate.

7. A laser exposure apparatus of an image scanning recording apparatus according to claim 5, wherein said beam modulating means comprises a multichannel type light modulator.

8. A laser exposure apparatus of an image scanning recording apparatus according to claim 4, wherein said polarizing means comprises means for converting said two laser beams into a pair of circularly polarized lights.

9. A laser exposure apparatus of an image scanning recording apparatus according to claim 7, wherein said means for converting into said pair of circularly polarized lights comprises a quarter-wave retardation plate.

10. A laser exposure apparatus of an image scanning recording apparatus according to claim 4, wherein said polarizing means comprises means for converting said two laser beams to a pair of elliptically polarized lights.

11. A laser exposure apparatus of an image scanning recording apparatus according to claim 4, wherein said beam synthesizing means comprises a polarizing beamsplitter.

12. A laser exposure apparatus of an image scanning recording apparatus according to claim 4, wherein said polarizing means comprises a half-wave retardation plate.

13. A laser exposure apparatus of an image scanning recording apparatus according to claim 3, wherein said means for preventing interference of the laser beam comprises means for changing optical path difference for setting the optical path difference between said two laser beams longer than a coherence length.

14. A laser exposure apparatus of an image scanning recording apparatus according to claim 13, wherein said means for changing optical path difference comprises a right-angle prism.

15. A laser exposure apparatus of an image scanning recording apparatus according to claim 13, wherein said means for changing optical path difference comprises a mirror.

16. A laser exposure apparatus of an image scanning recording apparatus according to claim 2, comprising two laser light sources for irradiating said two laser beams.

17. A laser exposure apparatus of an image scanning recording apparatus according to claim 16, wherein said two laser light sources comprise a laser diode.

18. A laser exposure apparatus of an image scanning recording apparatus according to claim 1, wherein said beam synthesizing means synthesizes said at least two laser beams in a staggered arrangement, whereby said plurality of beam spot lines are arranged staggered.

19. A laser exposure apparatus of an image scanning recording apparatus according to claim 18, wherein said at least two laser beams comprise a pair of a plurality of laser beams, and

one and the other of said pair of laser beams irradiate said beam synthesizing means from different directions, respectively.

20. A laser exposure apparatus of an image scanning recording apparatus according to claim 19, wherein said beam synthesizing means comprises a half mirror.

21. A laser exposure apparatus of an image scanning recording apparatus according to claim 19, wherein said beam synthesizing means comprises a beamsplitter.

22. A laser exposure apparatus of an image scanning recording apparatus according to claim 19, wherein said beam synthesizing means comprises a polarizing beamsplitter.

23. A method for laser exposure of an image scanning recording apparatus in which a plurality of laser recording beams irradiate an image recording surface to form a serial beam spot line, and the laser recording beams scan in a main scanning direction orthogonally intersecting the direction of said spot line to expose the recording medium, said method comprising the steps of:

preparing at least two laser beams which do not interfere with each other even if overlapped, each having a plurality of beam spot lines;

independently modulating said at least two laser beams;

arranging respective serial beam spot line of said at least two laser beams in said line direction; and

exposing said recording medium using said aligned beam spot lines.

24. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 23, wherein said step of aligning respective serial beam spot lines of said at least two laser beams in said line direction comprises the step of aligning said respective serial beam spot lines so that portions thereof overlap with each other in said line direction.

25. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 24, wherein said step of preparing at least two laser beams which do not interfere with each other even if overlapped, each having a plurality of beam spot lines comprises the steps of:

preparing a single laser light source; and

splitting a laser beam irradiated from said single laser light source into at least two laser beams.

26. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 25, wherein said step of preparing two laser beams which do not interfere with each other even if overlapped comprises the step of preparing laser beams constituting a pair of orthogonal polarization with each other.

27. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 26, wherein

said laser beams constituting a pair of orthogonal polarization with each other have their directions of progress intersecting orthogonally with each other; and

said step of aligning said serial beam spot lines so that portion thereof overlap with each other in said line direction comprises the step of aligning by a beamsplitter provided on the directions of progress intersecting orthogonally with each other.

28. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 27, wherein said step of modulating said two laser beams comprises the step of modulating beams by a multichannel type light modulator.

29. A method for laser exposure of a laser exposure apparatus in an image scanning recording apparatus according to claim 26, wherein said step of preparing laser beams constituting a pair of orthogonal polarization comprises the step of preparing laser beams constituting a pair of linearly polarized lights.

30. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 26, wherein said step of preparing laser beams constituting a pair of orthogonal polarization comprises the step of preparing laser beams constituting a pair of circularly polarized lights.

31. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 26, wherein said step of preparing laser beams constituting a pair of orthogonal polarization comprises the step of preparing laser beams constituting a pair of elliptically polarized lights.

32. A method for laser exposure of a laser exposure of a laser exposureapparatus of an image scanning recording apparatus according to claim 25, wherein said step of preparing at least two laser beams which do not interfere with each other even if overlapped comprises the step of setting an optical path difference between said at least two laser beams longer than a coherence length.

33. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 32, wherein said step of setting the optical path difference of said at least two laser beams longer than a coherence length comprises the step of setting the difference longer than the coherence length by passing one of said at least two laser beams through a prism.

34. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 32, wherein said step of setting the optical path difference of said two laser beams longer than a coherence length comprises the step of setting the path difference longer than the coherence length by making one of said two laser beams go by a detour by a mirror M9.

35. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 24, wherein said step of preparing two laser beams comprises the step of preparing two laser light sources.

36. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 35, wherein said step of preparing two laser light sources comprises the step of preparing two laser diode light sources.

37. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 23, wherein said step of aligning respective serial beam spot lines of said at least two laser beams in said line direction comprises the step of aligning the respective serial beam spot lines of said at least two laser beams in a staggered manner.

38. A method for laser exposure of a laser exposure apparatus of an image scanning recording apparatus according to claim 37, wherein

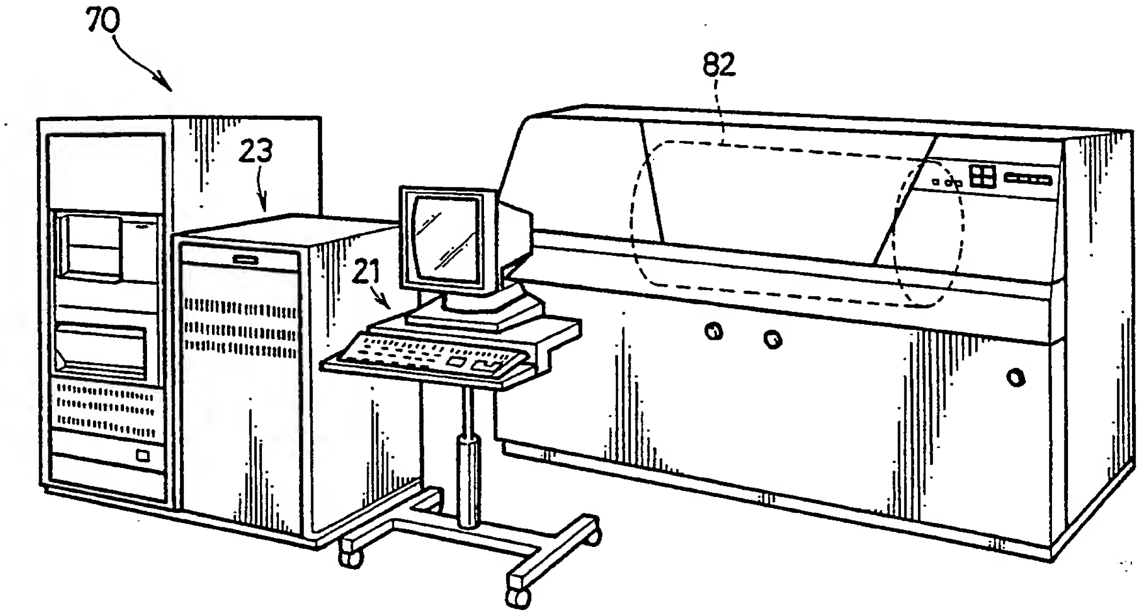
said at least two laser beams comprise a pair of plurality of laser beams, and

said step of arranging beam spot lines of said at least two laser beams in a staggered manner comprises the steps of,

emitting one of said pair of laser beams in one direction and emitting the other laser beam in a direction different from the said one direction, and

reflecting said one and the other laser beams in the same direction.

FIG.1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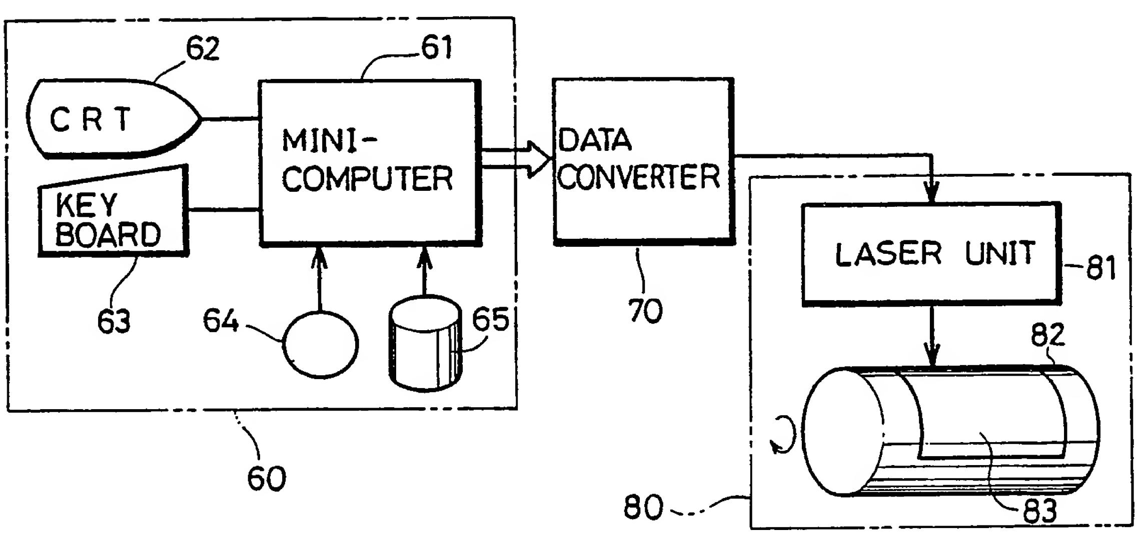
82
23
21

FIG.2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CRT
MINI-
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CONVERTER
KEY
BOARD
LASER UNIT
81
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80
83

FIG.3

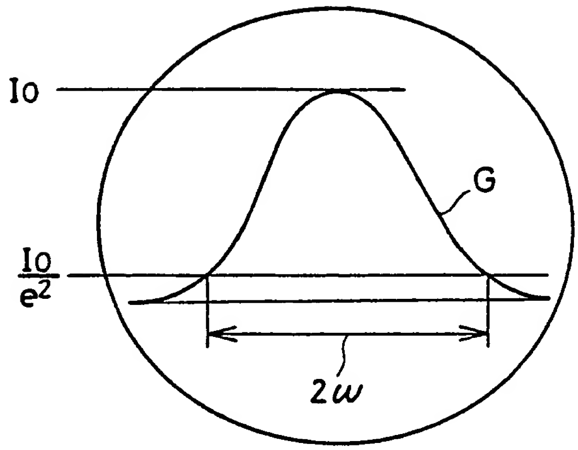


FIG.4

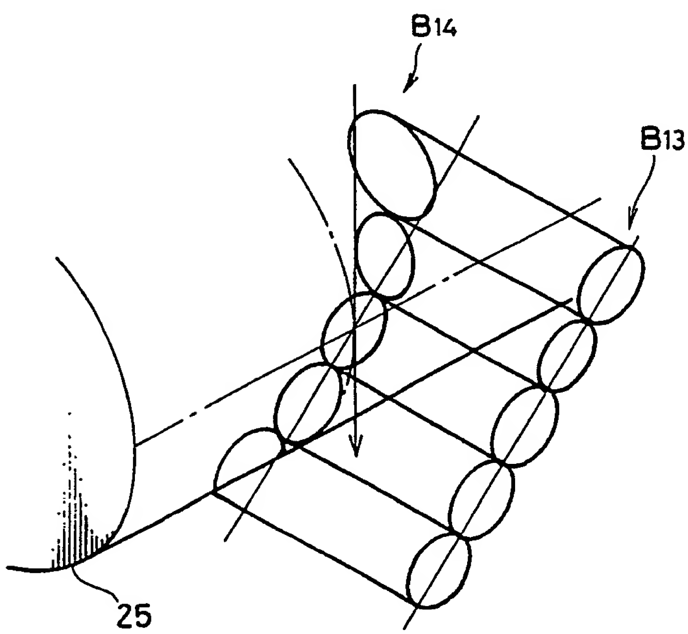


FIG.5

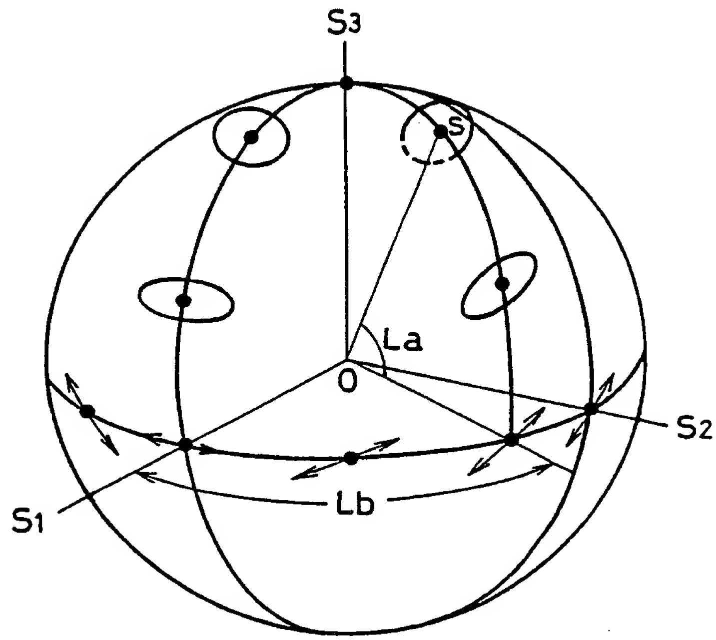
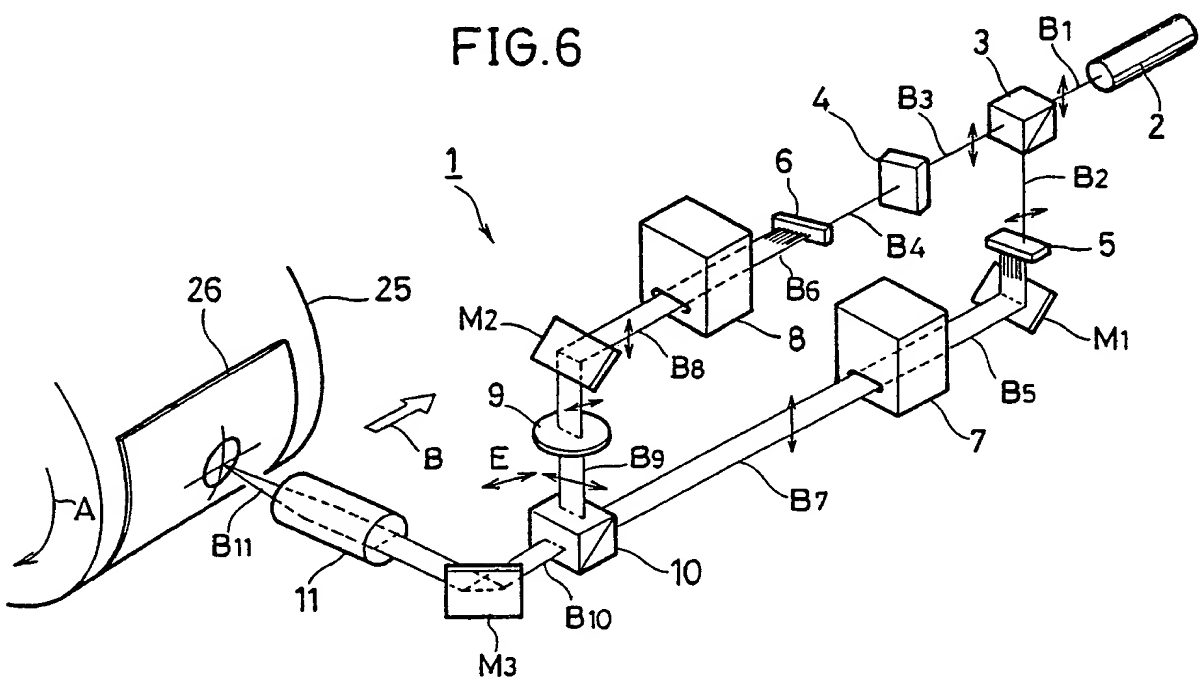

S3
S
La
O
S2
S1
Lb

FIG.6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B3
1
6
B2
B4
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26
25
B6
M2
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M1
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B5
9
7
B
E
B9
A
B7
B11
10
11
B10
M3

FIG.7

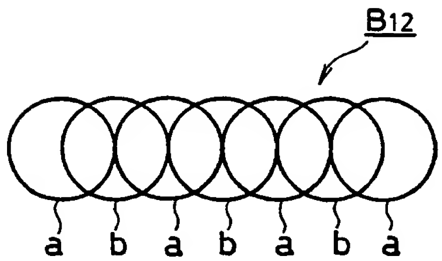


FIG.8

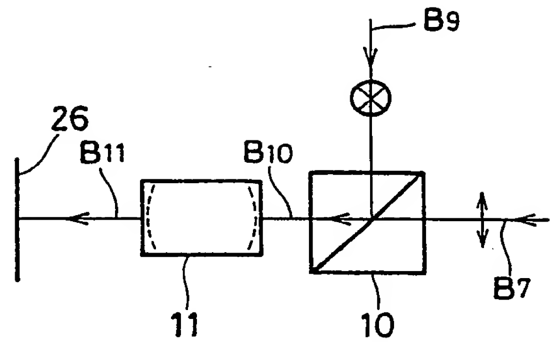


FIG.9

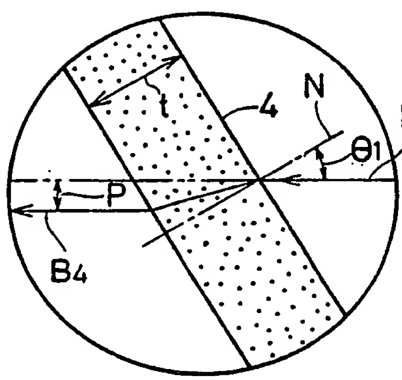


FIG.10

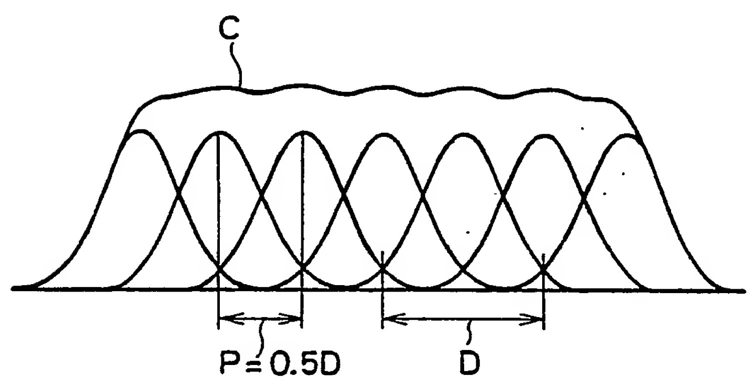


FIG.11

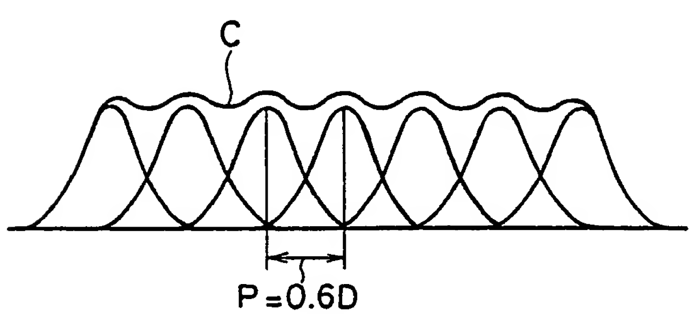


FIG.12A

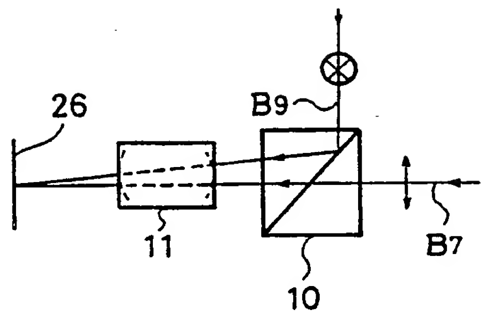


FIG.12B

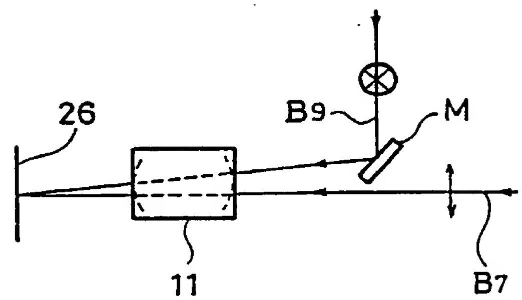


FIG.13

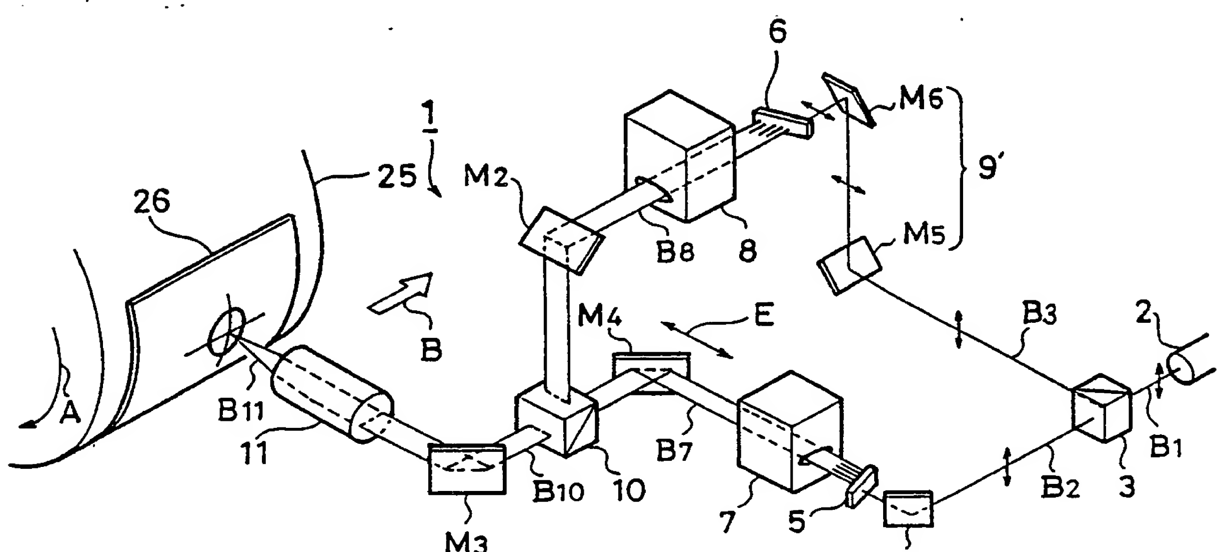
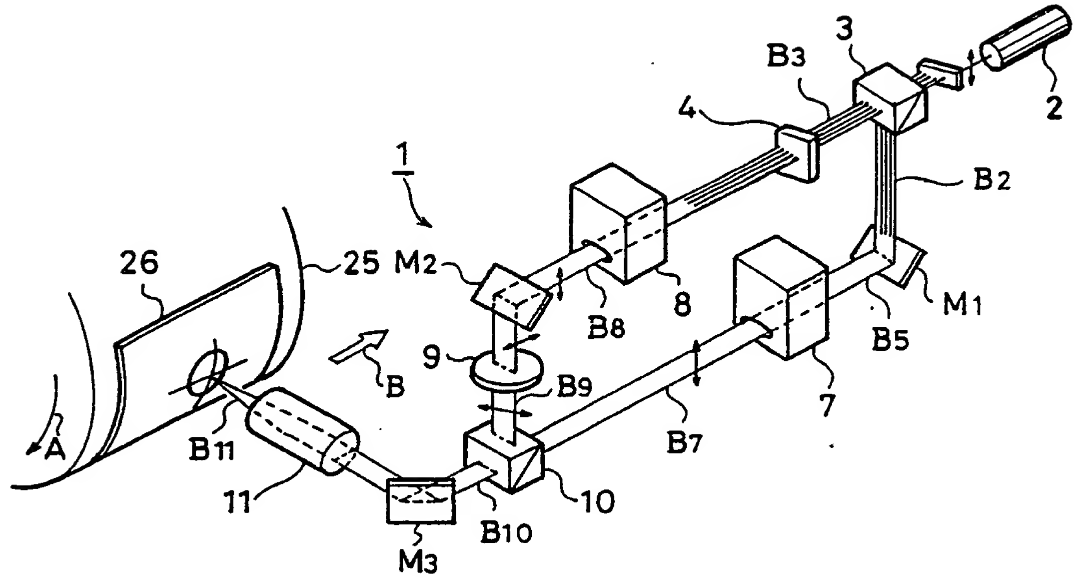


FIG.14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4
B2
26
25
M2
8
M1
B8
B5
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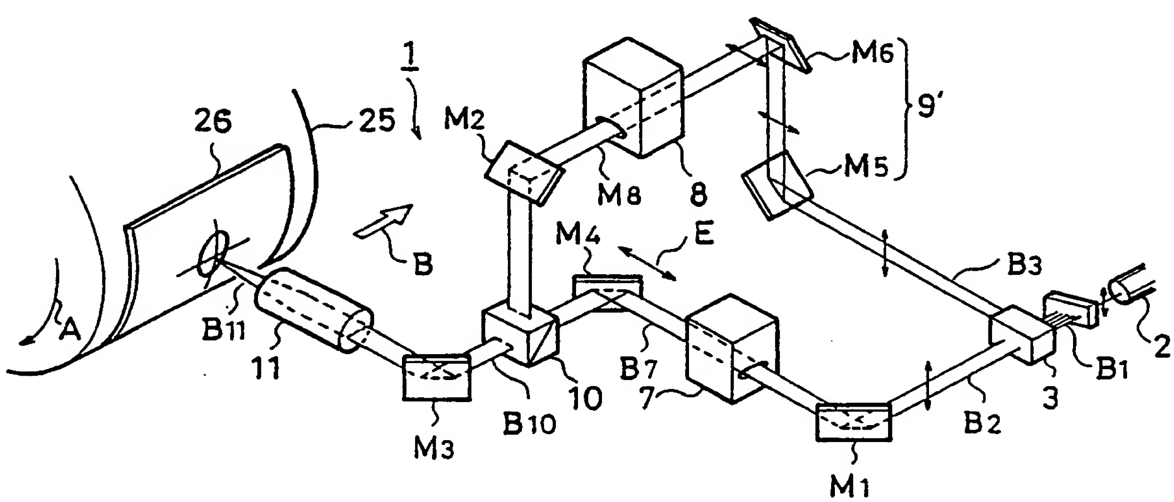
B9
7
A
B11
B7
11
10
B10
M3

FIG.15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M6
26
25
M2
9'
M5
M8
8
M4
E
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B3
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B7
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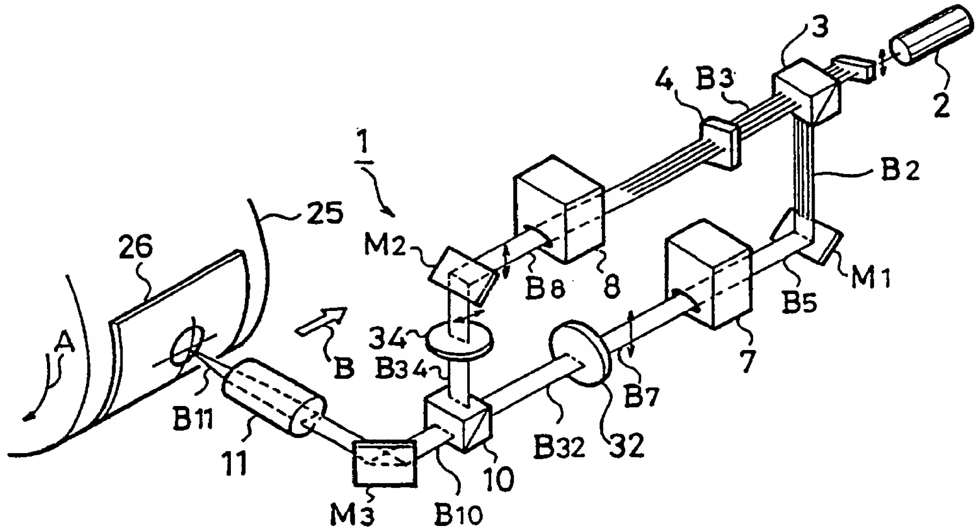
M3
M1

FIG.16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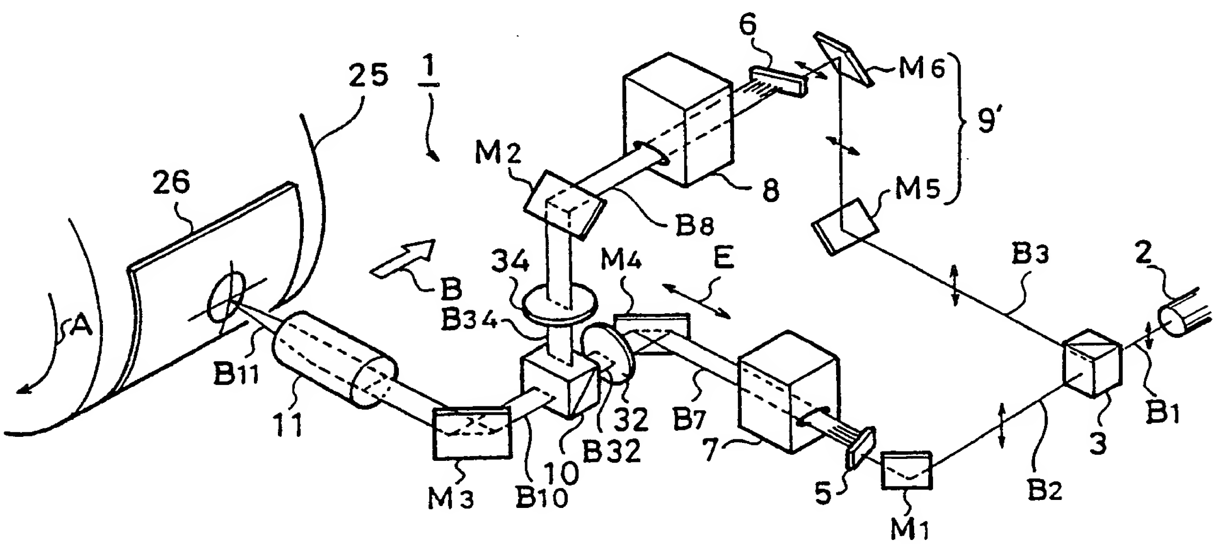
B32
32

FIG.17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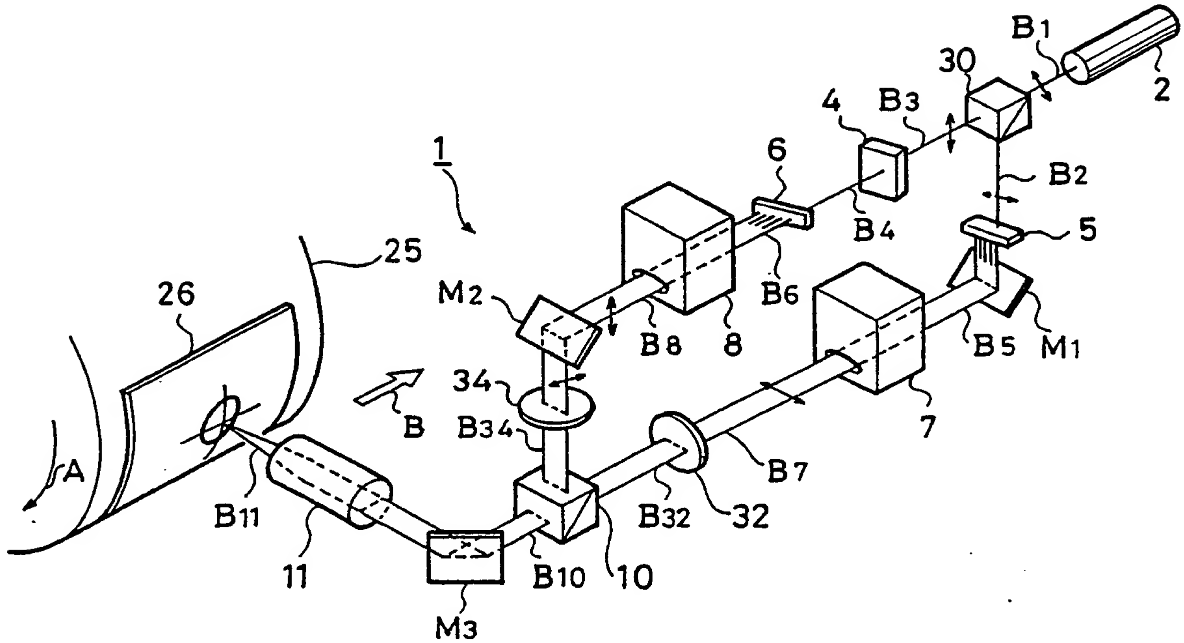
M1
B2

FIG.18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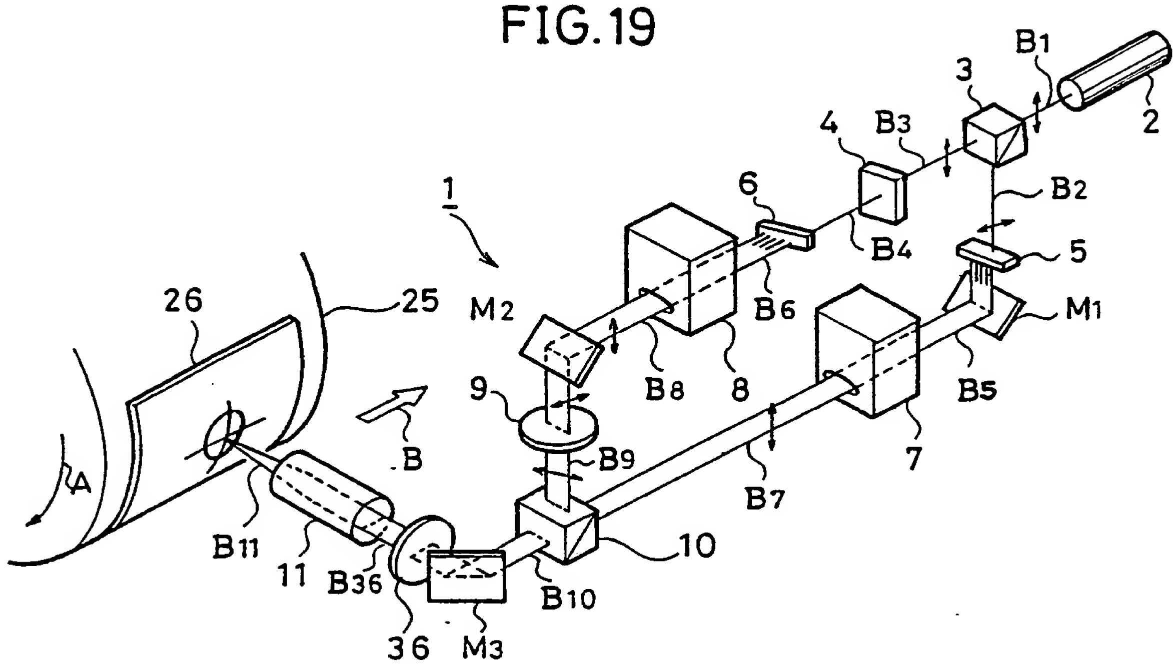
B10
10
M3

FIG.19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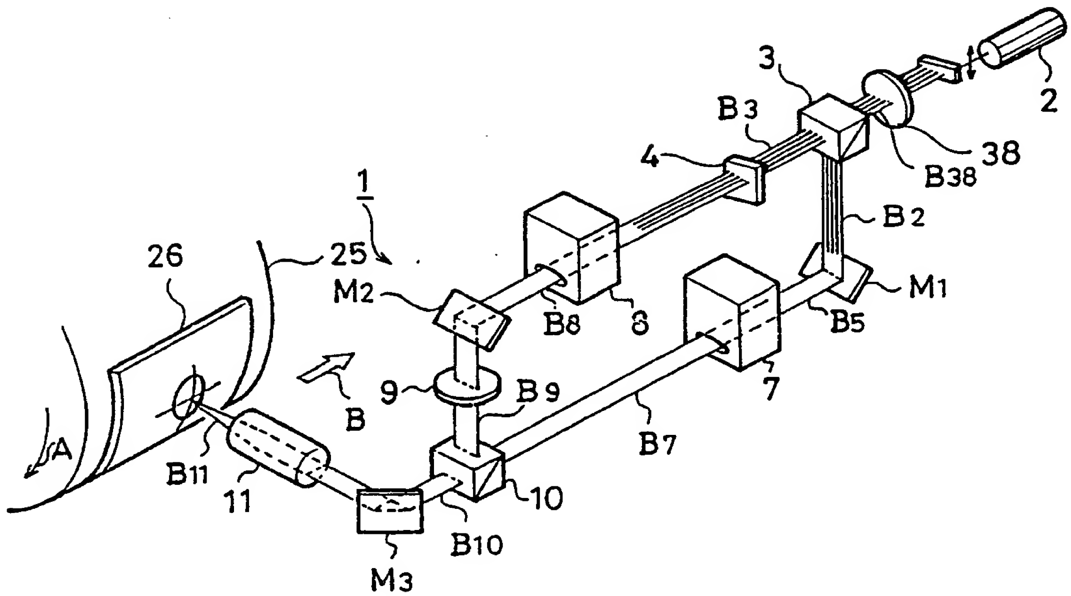
B36
B10
36
M3

FIG. 20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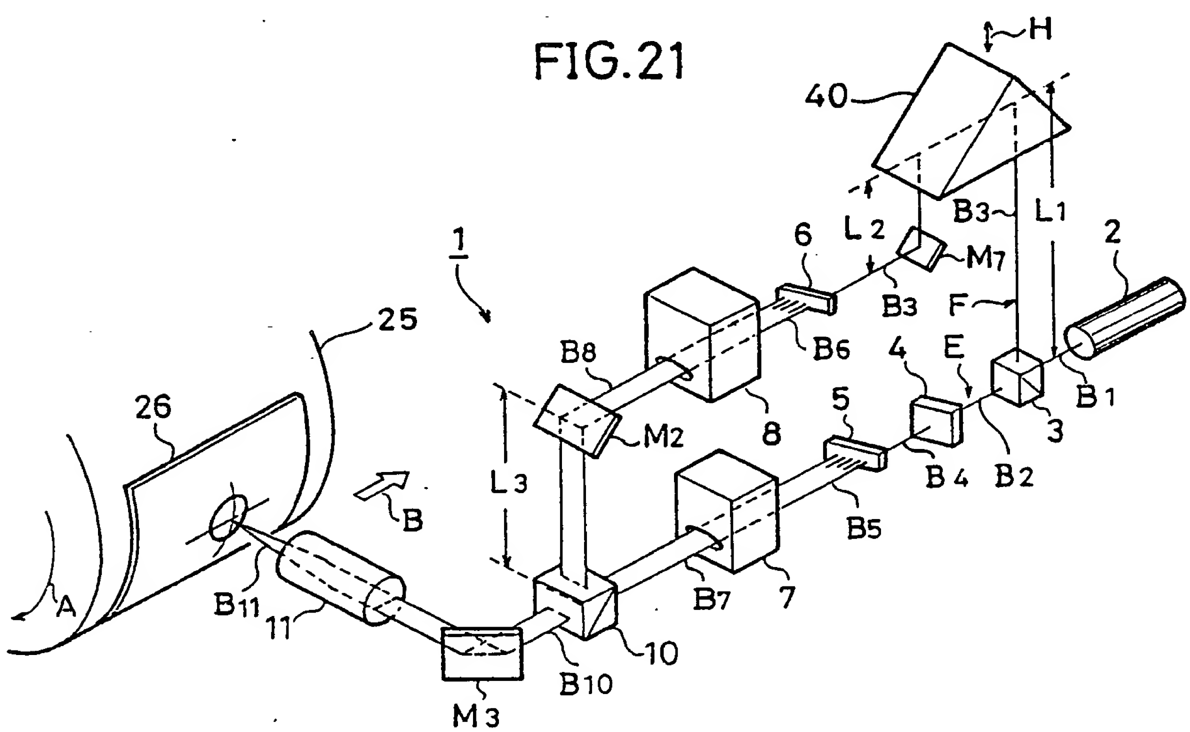
10
M3
B10

FIG.21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L2
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6
M7
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F
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E
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10
B10
M3

FIG.22

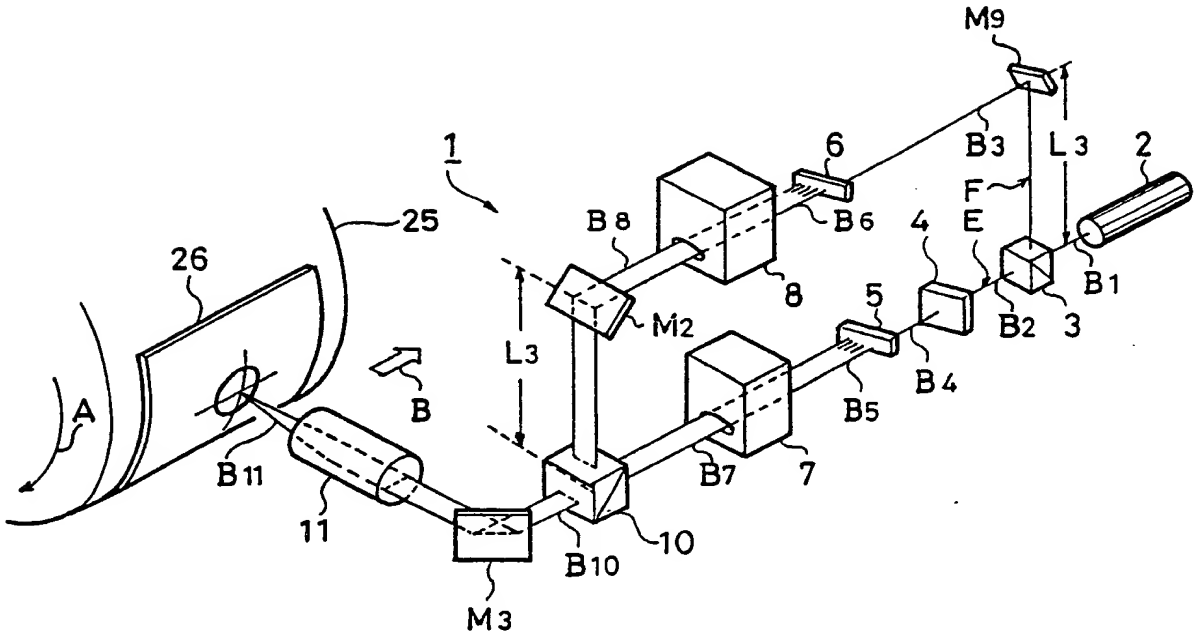

M9
1
6
B3
L3
2
F
25
B8
B6
4
E
26
B1
8
M2
5
B2
3
L3
B
B5
B4
A
B11
B7
7
11
10
B10
M3

FIG.23

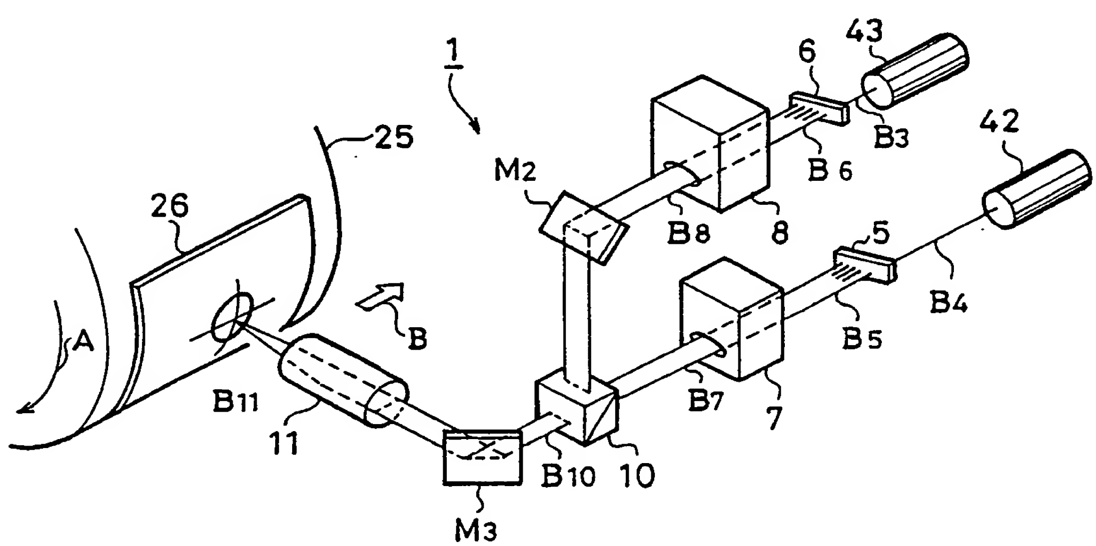

1
6
43
25
B3
M2
B6
42
26
B8
8
5
B4
A
B
B5
B11
B7
7
11
B10
10
M3

FIG.24

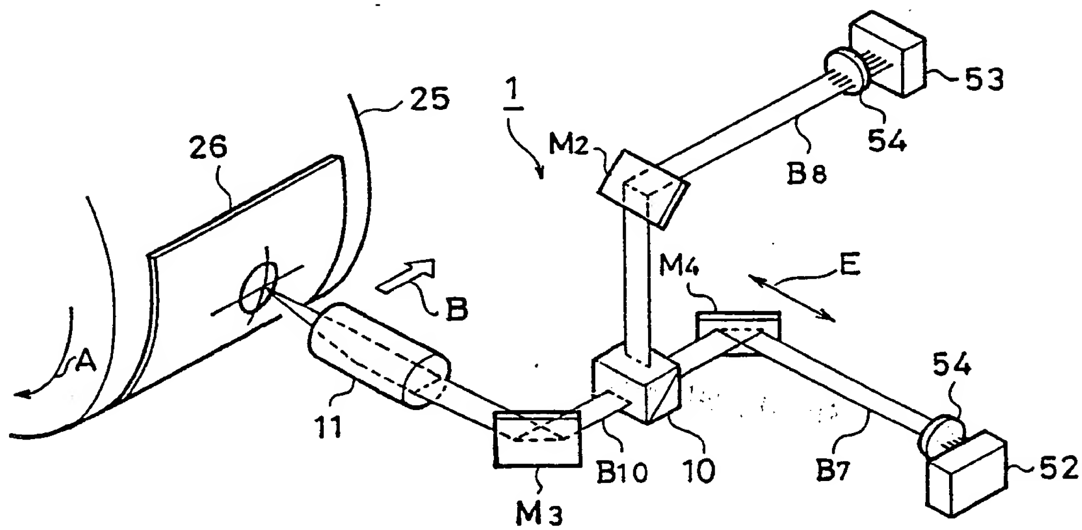


FIG.25

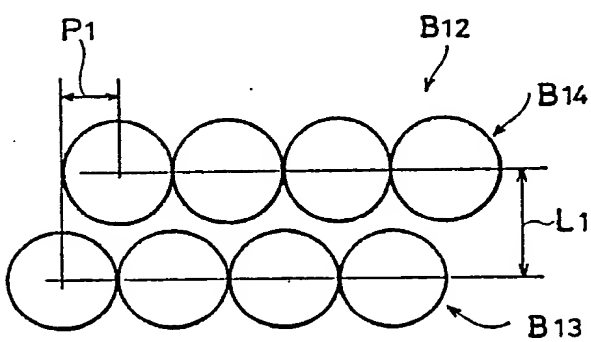
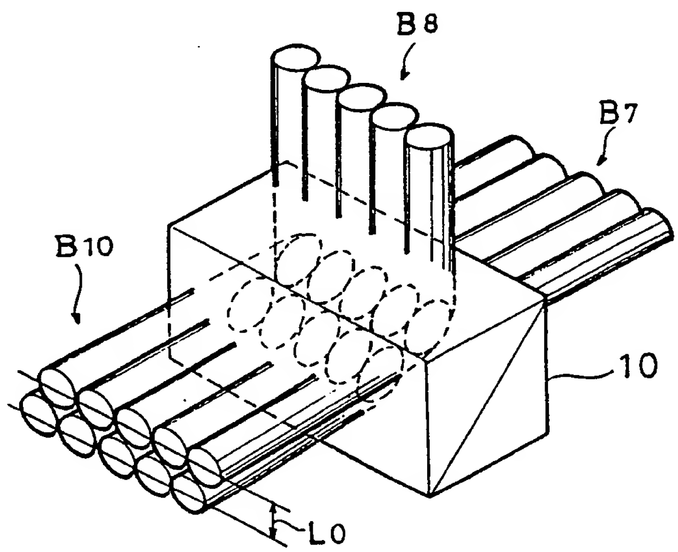


FIG.26



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(71) Applicant: Dainippon Screen Mfg. Co., Ltd.
1-1, Tenjinkitamachi Teranouchi-Agaru
4-chome Horikawa-Dori
Kamikyo-ku Kyoto 602(JP)

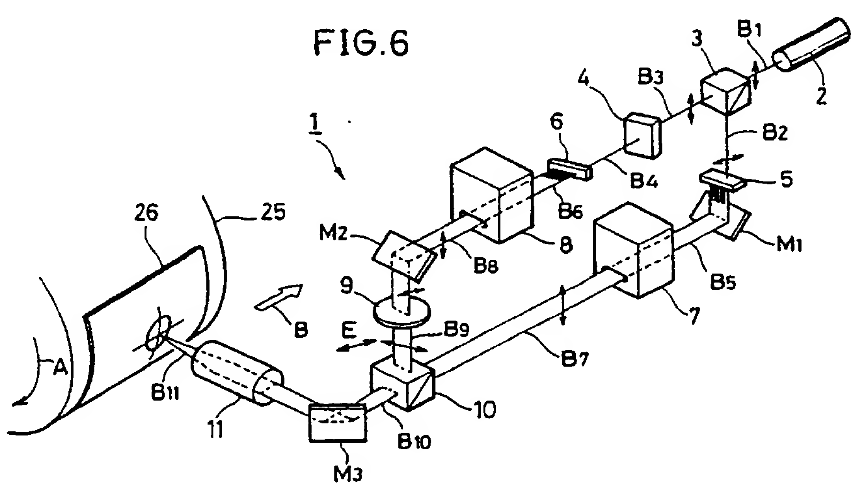
(72) Inventor: Okazaki, Masahide
c/o Dainippon Screen Kuze Plant 465-1
Tsukiyama-ch
Kuze Minami-ku Kyoto(JP)

(74) Representative: Goddar, Heinz J., Dr. et al
FORRESTER & BOEHMERT
Widenmayerstrasse 4/I
W-8000 München 22(DE)

(54) **Method and apparatus for laser exposure in an image scanning/recording apparatus.**

(57) A laser exposure apparatus of an image scanning recording apparatus comprises a single laser light source 2, a beamsplitter 3 for dividing a laser beam emitted from the single laser light source 2 into two laser beams, a modulator 7, 8 for modulating two laser beams in accordance with a recording signal, a half-wave retardation plate 9 for polarizing one of the beams in association with the other one of the beams so that the modulated laser beams constitute a pair of orthogonal polarization, a polarizing beamsplitter 10 for arranging two beams constituting a pair of orthogonal polarization with each other orthogonally in a line, and an optical system 11 for reducing the laser beams arranged in a line.

FIG.6



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EUROPEAN SEARCH REPORT

Application Number

EP 88 11 1219

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-2 709 354 (CROSFIELD ELECTRONICS) * Page 7, lines 3-18; page 11, line 23 - page 12, line 2; page 14, line 18 - page 15, line 5; figure 2 * – – –	1-3,23	H 04 N 1/036 H 04 N 1/18
A		4,13, 16-18	
A	US-A-4 565 426 (CULLEN) * Abstract * – – – – –	4-6	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 04 N

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	11 January 91	VAN DER ZAAL R.

CATEGORY OF CITED DOCUMENTS

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